MELLON INSTITUTE

Quarterly Scientific Progress Report

Report No. 15

for the period

November 1, 1961 - January 31, 1962

STRESS CORROSION OF HIGH STRENGTH STEELS AND ALLOYS; ARTIFICIAL ENVIRONMENT

Research Project No. 389-2

Sponsored by
U. S. Army Ordnance, Frankford Arsenal
Mr. H. Rosenthal, Contract Monitor

Contract No. DA-36-034-ORD-3277RD

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Dr. H. L. Anthony
Staff Adviser

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This Report Presented By The
Project Staff

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ABSTRACT

A brief review of experimental procedures, including test methods, apparatus, sample preparation, and testing is presented for reference purposes.

Cumulative stress corrosion test data for the various bent beam and U-bend tests on high strength missile alloys are given. Included are bent beam data for D6Ac, Vascojet 1000, AM355, PH15-7 Mo, B120VCA, and 4137 Co and U-bend data for 300M, AM355, PH15-7 Mo, B120VCA, 4137 Co, Ardeform 301, and U-modified 4137 Co.

While testing is not as yet complete and has not progressed to a sufficient degree in all cases for adequate summation, the low alloy steels 4137 Co, 300M, and Vascojet 1000 are definitely susceptible to stress corrosion in varying degree. The AM355, PH15-7 Mo, B120VCA, and Ardeform 301 alloys are not susceptible, regardless of strength level of exposure.

Alloy modification of the 4137 Co with uranium has very markedly decreased the stress corrosion susceptibility of this alloy.

I. INTRODUCTION

The project work described herein represents a portion of a grant made available by the Army to promote a general scientific advancement in the area of case materials for missiles. This specific project is concerned with the synthetic environment stress corrosion testing of specified high strength steels and alloys. The research objectives of the project were presented in Report No. 1.

Natural environmental tests on high strength steels and alloys are being conducted by Aerojet General Corporation, with actual production environments and rocket propellant environments being utilized. By prior mutual agreement, the same steel and alloy sheet material will be used for both projects and possible heat treatment variations will be circumvented by exchanging heat treated material whenever possible.

For the tests described herein, bent beam and U-bend samples were cut and machined from available sheet material and subjected to stress corrosion testing in five selected synthetic environments in the laboratory.

This report presents further information on continuing U-bend and bent beam tests for the assigned alloys, and for Rocoloy 270, 4137 Co, and Ardeform 301 missile steels.

II. EXPERIMENTAL PROCEDURES

Test Methods

A discussion of the U-bend and bent beam test methods together with an outline of the synthetic stress corrosion test environments used in performing the research are given in the July, 1960, Monthly Scientific Report, Report No. 1.

All recently-exposed (and future) samples being subjected to stress corrosion testing are being weighed prior to exposure to the test solutions to provide, whenever possible, general corrosion information.

Apparatus

Schematic drawings of bent beam sample holders, the U-bend test holders, a sample bending device for bent beam specimens, and a stress corrosion test tank were presented in Report Nos. 1 and 3.

Polyethylene containers are presently being used for the stress corrosion exposure of U-bend specimens to the various synthetic environments. Each container will adequately hold six U-bend specimens. The use of these containers will supplement the sample testing presently being conducted in epoxy-coated tanks. Bent beam specimens are being tested in heavy glass dishes and epoxy-coated metal tanks.

Construction of shelving and an aeration system (Report No. 6) together with other pertinent items has facilitated (wherever feasible) the transfer of some samples under test from the glass containers to the epoxy-coated test tanks. The completed facility is illustrated in Report No. 7.

Alloy Sample Material

The alloys being used in the study on stress corrosion include:

1. Low Alloy: Ladish D6Ac
2. Si-Modified 4300 Series: 300M.
3. Hot-Worked Die Steel: Vascojet 1000.
4. Cold-Worked PH Steel: AM355.
5. Heat-Treated PH Steel: PH15-7 Mo.
6. Titanium Alloy: B120VCA.
7. Low Alloy-Cobalt Modified: 4137 Co.
8. Low Alloy-Cobalt Modified: Rocoloy 270.
9. Stretch-Formed 17/7 Stainless Steel: Ardeform 301.
10. Low Alloy-Co and U-Modified: 4137 Co.

All of the sample material is being tested in sheet form and was procured as such.

Chemical analyses for the above listed alloys and for the comparative heats are given in their entirety in Table I in Report

No. 13. Physical properties and heat treating surveys for the alloys were presented in Report No. 12.

Sample Preparation

Sheet material of the various alloys was sheared into slightly over-size U-bend, bent beam, and tensile specimens in both the primary (direction of lowest Y.S.) and secondary directions. The specimens were then wet-ground to width, length, and thickness (if necessary). Sample thickness was maintained between 30 and 50 mils, and as close to 50 mils as possible.

After heat treatment surveys were conducted (see Report No. 12) to determine the Y.S. variation with tempering temperature for each alloy (not necessary for AM355), the specimens were heat treated to strength levels approximating 200, 220, 240 Kpsi and maximum Y.S. Heat treating of the B120VCA alloy consisted of aging in an inert atmosphere (see Report No. 12).

All the surfaces except the ends of the heat treated specimens were then polished with emery paper to remove oxide films, the final polish being administered with 240-grit emery. Care was taken to assure a uniformly square edge on the specimens. A tendency of the D6Ac, V-1000, and 300M specimens to decarburize was circumvented by carefully wet-grinding the surfaces of the heat-treated samples an additional 5 mils per surface.

Tensile and metallographic samples were also cut from the alloy sheet material for the determination of as-received and heat-treated physical properties.

Sample Testing

The U-bend specimens were bent into a V-shape with a special bending apparatus, sprung into clips (see Report No. 12), and immersed in each of the five test solutions (one-molar NaCl, Na_2SO_4, $NaNO_3$, $NaPO_3$, and Na_2S).

The bent beam specimens were precision-cut to length ($\pm$ 0.005 inches) and sprung into a holder with a bending device (see Report No. 12). Immersion in the above five solutions constituted the test phase.

Status of Sample Material

The present status of the alloy sample material to date:

1. D6Ac - heat treatment complete; some bent beam samples being tested.
2. 300M - heat treatment complete; some U-bend data available.
3. Vascojet 1000 - heat treatment complete; some bent beam data available.
4. AM355 - all U-bends and all bent beam samples under test.

5. PH15-7 Mo - all U-bends and some bent beam samples under test.
6. B120VCA - heat treatment complete; some U-bend and bent beam samples under test.
7. 4137 Co - various U-bends under test.
8. Rocoloy 270 - undergoing final machining.
9. Ardeform 301 - U-bends under test.

III. EXPERIMENTAL

Sample preparation, heat treatment, metallographic examination, and stress corrosion testing of all alloys, both assigned materials and additional samples accepted for study, are continuing.

A. Sample Preparation and Heat Treatment

During the period of this report, the 300M samples were heat treated to three yield strength levels of about 200, 220, and 250 Kpsi. The heat treatment schedule was in accordance with the information given in the heat treatment survey (see Report No. 12) for this alloy.

Surface cleaning of a considerable number of bent beam and U-bend samples subsequent to heat treating and precision cutting to length of bent beam samples constituted the greater portion of the work during this quarter. Wet grinding and emery polishing with 240-grit emery cloth as the final step, were utilized in removing oxide films from the samples. The bent beam samples were cut to length on a cut-off wheel with water coolant to the lengths required. Length calculation for stressing to 75% of the various yield strength levels was accomplished by the Phelps and Loginow method.*

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* Phelps, E. H., and Loginow, A. W., "Stress Corrosion of Steels for Aircraft and Missiles," Corrosion 16, July (1960), 97-107.

Tabular data pertinent to the length calculation was supplied by Dr. Phelps and was utilized in this work.

Sample preparation for the investigation of coatings and their contribution to alleviation of stress corrosion failure has been initiated. Since surface tension effects associated with any dip-coating composition will tend to leave an uncoated edge if that edge is square, all these samples will have rounded edges for coating and testing. Uncoated control samples of these alloys will be run simultaneously for comparative purposes.

B. Stress Corrosion Testing

During this report period, a number of Vascojet 1000, D6Ac, AM355, PH15-7Mo, and B120VCA bent beam samples were subjected to synthetic environment stress corrosion testing. U-bend specimens of 300M and a uranium-modified 4137 Co alloy were also subjected to testing during this period. A more detailed discussion of the results to date for these alloys is provided in the following sections of this report.

1. Bent Beam Tests

Bent beam specimens of all assigned alloys except 300M are presently undergoing stress corrosion testing. These include:

a. D6Ac - Only the intermediate strength bent beam samples for this alloy have been subjected to stress corrosion

testing to date. The cumulative results, as illustrated in Table I, indicate that this alloy may prove to be superior in stress corrosion resistance to the other low alloy, high-strength steels (V-1000, 300M, and 4137 Co).

b. Vascojet 1000 - Data for bent beam specimens from all three yield strength levels are available for this alloy. Data obtained from exposure of primary direction (transverse) samples are given for the low strength level (~205 Kpsi) in Table II, for the intermediate strength level (~245 Kpsi) in Table III, and for the secondary direction (longitudinal), high strength level (~260 Kpsi) in Table IV.

Even though the results are limited essentially to one direction per strength level at this time, we can conclude the alloy is susceptible to stress corrosion failure at the high and intermediate yield strength levels in all but the sulfide environment. In the chloride environment it is apparently susceptible at all strength levels. The reason for the disparity in failure time in nitrate solution between the intermediate (Table III) and high (Table IV) strength levels is not immediately apparent.

To date, the low strength (Table II) specimens have not shown a susceptibility to stress corrosion in the nitrate, sulfide, sulfate, or phosphate solutions.

Table IV also provides a comparison between 4-inch and 7-inch specimens, secondary direction, in chloride and nitrate solutions. The results are of the same order of magnitude in both average time to failure and failure time range. We may conclude from this that specimen length is of little consequence if the $\frac{\sigma}{E}$ versus $\frac{L-H}{H}$ point calculated for the specimen falls on the section of greater slope of the H/t curve shown in Figure 2 of the Phelps-Loginow publication.

c. AM355 - Although the primary (transverse) direction specimens (Table V) have been under test for only a relatively short period, the secondary direction (longitudinal or rolling direction) samples (Table VI) have undergone exposure for a considerable period. No failures to date have been recorded at any of the three yield strength levels in the five synthetic environments. For all practical purposes, this alloy material is not susceptible to stress corrosion failure in the environments utilized.

The Table VI specimens were removed from their holders after approximately 300 days of environmental testing so that the holders could be utilized for other samples. Some permanent set was noted in the samples after removal. This is not surprising, considering the shape of the tensile curve for this alloy, in that there is little or no linear relationship between stress and strain

below the 0.2% offset Y.S. The tensile curve describes a sweeping arc to fracture.

d. PH15-7Mo - Samples from only one direction at the highest attainable yield strength (~290 Kpsi) have been exposed to stress corrosion testing to date. There have been no failures, however, in any test environment, as indicated in Table VII. We can conclude, on a preliminary basis, that the alloy is not prone to stress corrosion.

e. B120VCA - Preliminary data for one direction at the high strength level (~200 Kpsi) are given in Table VIII. No failures have been recorded to date and the alloy does not seem to be stress corrosion sensitive.

f. 4137 Co - There has been no change during this report period of the status of the 4137 Co bent beam samples with the exception of one sample failure in the 75% of Y.S. group, 175 Kpsi applied stress, severe industrial exposure.

A discussion of the results obtained from these natural environment exposures has been presented in Report Nos. 12, 13, and 14. The cumulative data for the three environments are presented in Tables IX and X for reference purposes.

2. U-bend Tests

During this report period, a number of U-bend samples of 300M, AM355, and U-modified 4137 Co have been exposed to the various synthetic test environments. The cumulative data to date for all alloys under test are discussed in the following sections of this report.

a. 300M - A number of 300M U-bend specimens of both the Primary Heat and Comparative Heat sheet materials were subjected to stress corrosion testing in the five synthetic environments. All samples from the low (~200 Kpsi Y.S.), intermediate (~220 Kpsi Y.S.), and high strength (~250 Kpsi Y.S.) groups for both directions (primary and secondary) have not been exposed to the test solutions. However, the cumulative results to date are given in Tables XI, XII, XIII, and XIV.

On a preliminary basis, the alloy shows a susceptibility to stress corrosion and the results are of approximately the same order of magnitude as those obtained for the 4137 Co alloy. The low (Table XI) and intermediate (Table XII) strength samples were unaffected in all but the phosphate solution, in which all samples failed in minutes or hours. The exposure time has been too short to permit further comparison.

Failure time for the high strength 300M samples (Tables XIV and XV) was of the order of minutes or hours in all except the sulfide environment, in which no failures were recorded for any strength level. The agreement among the times to failure of the Primary Heat and Comparative Heat high strength samples was not too good, indicating a possible considerable variation from heat to heat for this alloy.

b. AM355 - The cumulative U-bend test results for this alloy are presented in Tables XV (low strength), XVI (intermediate strength), and XVII (high strength). Sample failures have only been recorded in the chloride test solution and more predominantly in the primary direction samples.

The possibility that the samples were subjected to tensile-surface cracking during bending was investigated for the low strength (Table XV), primary direction samples prior to immersion during this report period. Surface cracking was observed under 10-power and 30-power magnification and confirmed by cross-sectioning, polishing, and by subsequent metallographic examination. Since the bent beam AM355 samples (Tables V and VI) did not exhibit stress corrosion sensitivity, we can conclude that, while this alloy is not stress-corrosion prone even in the stressed (below the Y.S.) state, it is subject to possible failure in plastically-deformed areas

in a chloride environment. The crack size necessary for susceptibility is problematical.

c. PH15-7Mo - The cumulative data for the stress corrosion testing of PH15-7 Mo U-bends indicate that, after from 100 to 300 days of environmental exposure, the alloy is definitely not susceptible to stress corrosion failure. Not a single sample failure was recorded for any strength level in all five synthetic test environments. Tables XVIII through XXI present the results to date of PH15-7 stress corrosion U-bend tests.

Table XXII indicates that neither AM355 or PH15-7 Mo, in the strength levels tested, are susceptible to cracking in a chlorinated hydrocarbon, a non-chlorinated hydrocarbon, or a chlorinated non-hydrocarbon.

d. B120VCA - The U-bend samples of this alloy that were aged for 21, 94, and 200 hours at 900 F in sealed flasks in an argon atmosphere were found to be unsuitable for test purposes. The samples would not take the degree of plastic formation required to form a U-bend without breakage.

While every precaution was apparently taken in the preparation of these samples to avoid contamination through handling, overheating during machining, and residual air and moisture adsorption on the sample surface prior to or during aging, the effort was not successful in producing usable U-bend samples.

The cumulative U-bend stress corrosion data for the low strength samples is given in Table XXIII, for the Primary Heat, and in Table XXIV, for the Comparative Heat. No sample failures have been obtained and the alloy does not appear to be prone to stress corrosion.

e. 4137 Co - During this report period, there have been a few additional failures among the various 4137 Co U-bend samples. The remaining 3 samples of the low strength group (1100°F temper or 191 Kpsi Y.S.) in chloride solution failed. Also 4 intermediate strength (232 Kpsi Y.S.) samples and 1 low strength sample failed in the sulfate environment (see Table XXV).

The high strength (550°F temper or 258 Kpsi Y.S.) specimens failed in all but the sulfide environment within a few days, the failure rate being extremely rapid in the phosphate solution.

The intermediate strength (750°F temper or 232 Kpsi Y.S.) samples failed rapidly only in the phosphate and nitrate solutions, the chloride environment being somewhat less effective in inducing failure in these specimens.

The low strength (1100°F temper or 191 Kpsi Y.S.) samples failed within a few days only in the phosphate solution, a lessening degree of effectiveness in this respect being noted for the nitrate, chloride, sulfate, and sulfide solutions.

As Table XXVI indicates the 4137 Co U-bend samples were also prone to failure in a humid atmosphere, where only the low strength samples remain after over 300 days of exposure. No failures were obtained in the laboratory and dry air environments.

f. Ardeform 301 - The cumulative data to date for these samples are given in Tables XXVII and XXVIII. Sample failures were obtained only in the chloride solution for both sets of samples. The severity of the bend for the specimens undoubtedly led to surface cracking, especially in the longitudinal samples having the outside surface in tension (see Report No. 10, p. 9, for specimen preparation). However, only the chloride solution served to promote failure, a situation similar to that shown by the AM355 test data.

Although bent beam data are not available for the Ardeform 301 alloy, we can postulate that the alloy may be stress corrosion prone in the plastically-deformed condition in a chloride environment and may not be susceptible in the stressed condition in the elastic region.

g. U-modified 4137 Co - Alloy modification of the 4137 Co alloy with about 0.8 to 1.0% uranium was found to considerably inhibit the susceptibility of the high strength samples to stress corrosion failure, as indicated in Table XXIX. Comparison of the data with the Table XXV high strength 4137 Co alloy in a chloride

solution shows that the uranium modification has effected to date a change considerably in excess of one order of magnitude in stress corrosion resistance.

During preparation of the samples for testing it was also noted that surface discoloration (oxidation or general corrosion) was considerably more rapid than for other sample materials. Overnight exposure in the laboratory was sufficient in requiring additional surface polishing with 240-grit emery cloth.

IV. FUTURE WORK

It is anticipated that all the remaining U-bend specimens and most of the bent beam specimens will have been subjected to varying degrees of exposure in the synthetic test environments at the end of the next report period. This will include the comparative heat samples also.

Sample preparation for coating with various paint systems and the coating phase itself should also be complete with the samples under test.

The cumulative results for the bent beam and U-bend samples now being tested will also be presented.

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R: 2-19-62
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TABLE I

CUMULATIVE D6Ac STRESS CORROSION BENT BEAM TESTS

Intermediate Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Applied Stress* Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	206	154	6	none to 47 days	--	--
	Secondary	223	--	--	--	--	--
$NaNO_3$	Primary	206	154	6	none to 47 days	--	--
	Secondary	223	--	--	--	--	--
Na_2S	Primary	206	--	--	--	--	--
	Secondary	223	--	--	--	--	--
Na_2SO_4	Primary	206	154	6	none to 47 days	--	--
	Secondary	223	--	--	--	--	--
$NaPO_3$	Primary	206	154	6	none to 47 days	--	--
	Secondary	223	--	--	--	--	--

* Samples stressed to 75% of Y.S. in holder.
Specimens were austenitized at 1550° F for 20 min., oil quenched, and tempered at 840° F for 2 + 1 hrs., with an air quench after each temper.

TABLE II

CUMULATIVE VASCOJET-1000 BENT BEAM TESTS

Low Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Applied Stress* Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	207	155	6	6	29.7	24.5 to 36.5
	Secondary	--	--	-	-	--	--
$NaNO_3$	Primary	207	155	6	none to 71 days	--	--
	Secondary	--	--	-	-	--	--
Na_2S	Primary	207	155	6	none to 70 days	--	--
	Secondary	--	--	-	-	--	--
Na_2SO_4	Primary	207	155	6	none to 70 days	--	--
	Secondary	--	--	-	-	--	--
$NaPO_3$	Primary	207	155	6	none to 70 days	--	--
	Secondary	--	--	-	-	--	--

* Samples stressed to 75% of their Y.S. in holders; all 4-inch samples.

Note: These samples were austenitized at 1900°F for 40 min., oil quenched, and tempered for 2 + 2 + 2 hrs. at 1100°F with an air quench after each temper.
Primary direction is the direction of lowest Y.S. (transverse for this alloy).

TABLE III

CUMULATIVE VASCOJET-1000 BENT BEAM TESTS

Intermediate Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Applied Stress* Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	246	184	6	6	0.5	3 hrs. to 1 day
	Secondary	--	--	-	-	--	--
$NaNO_3$	Primary	246	184	6	6	3.9	2.5 to 5.5
	Secondary	--	--	-	-	--	--
Na_2S	Primary	246	184	6	none to 56 days	--	--
	Secondary	--	--	-	-	--	--
Na_2SO_4	Primary	246	184	6	6	1.5	0.5 to 3.5
	Secondary	--	--	-	-	--	--
$NaPO_3$	Primary	246	184	6	6	0.5	4 hrs. to 1 day
	Secondary	--	--	-	-	--	--

* Samples stressed to 75% of their Y.S. in holders; all 4-inch samples.

Note: These samples were austenitized at 1900°F for 40 min., oil quenched, and tempered for 2 + 2 + 2 hrs. at 850°F with an air quench after each temper.
Primary direction is the direction of lowest Y.S. (transverse for this alloy).

TABLE IV

CUMULATIVE VASCOJET-1000 BENT BEAM TESTS

High Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Applied Stress* Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	--	--	-	-	--	--
	Secondary	260	195	6	6	0.6	1 hr. to 0.5 days
	Secondary**	260	195	6	6	0.3	2 hrs. to 0.5 days
$NaNO_3$	Primary	--	--	-	-	--	--
	Secondary	260	195	6	6	19.0	8.5 to 25.5
	Secondary**	260	195	6	6	22.3	8.5 to 28.5
Na_2S	Primary	--	--	-	-	--	--
	Secondary	260	195	-	-	--	--
Na_2SO_4	Primary	--	--	-	-	--	--
	Secondary	260	195	6	6	1.4	0.5 to 3
$NaPO_3$	Primary	--	--	-	-	--	--
	Secondary	260	195	6	6	3.3 hrs.	1.6 hrs. to 5 hrs.

* Samples stressed to 75% of their Y.S. in holders.

** Seven-inch bent beam specimens; all others are four-inch.

Note: These samples were austenitized at 1900°F for 40 min., oil quenched, and tempered for 2 + 2 + 2 hrs. at 975°F with an air quench after each temper.
Primary direction is the direction of lowest Y.S. (transverse for this alloy).

TABLE V

CUMULATIVE AM355 STRESS CORROSION BENT BEAM TESTS

Primary (Lowest Y.S.) Direction

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Applied Stress* Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	224	168	4	none to 33 days	--	--
	Primary	235	176	4	none to 33 days	--	--
	Primary	274	205	4	none to 33 days	--	--
$NaNO_3$	Primary	224	168	4	none to 33 days	--	--
	Primary	235	176	4	none to 33 days	--	--
	Primary	274	205	4	none to 33 days	--	--
Na_2S	Primary	224	168	--	--	--	--
	Primary	235	176	--	--	--	--
	Primary	274	205	--	--	--	--
Na_2SO_4	Primary	224	168	4	none to 33 days	--	--
	Primary	235	176	4	none to 33 days	--	--
	Primary	274	205	4	none to 33 days	--	--
$NaPO_3$	Primary	224	168	4	none to 33 days	--	--
	Primary	235	176	4	none to 33 days	--	--
	Primary	274	205	4	none to 33 days	--	--

* Samples stressed to 75% of Y.S. in holder.
Sheet material rolled to strength by vendor; three Y.S. levels are 224, 235, and 274 Kpsi.
Primary direction is direction of lowest Y.S. (transverse direction for this alloy).

TABLE VI

CUMULATIVE AM355 STRESS CORROSION BENT BEAM TESTS

Test Solution	Direction* of Specimen	Applied Stress Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Secondary	180	6	none to 302 days	--	--
	Secondary	195	6	none to 286 days	--	--
	Secondary	226	6	none to 299 days	--	--
$NaNO_3$	Secondary	180	6	none to 302 days	--	--
	Secondary	195	6	none to 286 days	--	--
	Secondary	226	6	none to 299 days	--	--
Na_2S	Secondary	180	6	none to 302 days	--	--
	Secondary	195	6	none to 286 days	--	--
	Secondary	226	6	none to 299 days	--	--
Na_2SO_4	Secondary	180	6	none to 302 days	--	--
	Secondary	195	6	none to 291 days	--	--
	Secondary	226	6	none to 304 days	--	--
$NaPO_3$	Secondary	180	6	none to 302 days	--	--
	Secondary	195	6	none to 291 days	--	--
	Secondary	226	6	none to 304 days	--	--

Note: These specimens were cold-rolled to strength level.
The outer surface of the specimens is stressed to 75% of its Y.S.
(250 Kpsi, 261 Kpsi, and 302 Kpsi, resp.)
Above tests considered complete as of January 2, 1962.

* Primary direction is direction of lowest Y.S. (transverse direction for this alloy).

TABLE VII

CUMULATIVE PH15-7Mo STRESS CORROSION BENT BEAM TESTS

High Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Applied Stress* Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	296	214	4	none to 41 days	--	--
	Secondary	--	--	--	--	--	--
$NaNO_3$	Primary	286	214	4	none to 41 days	--	--
	Secondary	--	--	--	--	--	--
Na_2S	Primary	286	214	4	none to 41 days	--	--
	Secondary	--	--	--	--	--	--
Na_2SO_4	Primary	286	214	4	none to 41 days	--	--
	Secondary	--	--	--	--	--	--
$NaPO_3$	Primary	286	214	4	none to 41 days	--	--
	Secondary	--	--	--	--	--	--

* Samples stressed to 75% of Y.S. in holder.
CR sheet material tempered 1 hr. at 900°F.
Primary direction is direction of lowest Y.S. (transverse direction for this alloy).

TABLE VIII

CUMULATIVE B120VCA STRESS CORROSION BENT BEAM TESTS

High Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Applied Stress* Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	--	--	--	--	--	--
	Secondary	198	148	4	none to 41 days	--	--
$NaNO_3$	Primary	--	--	--	--	--	--
	Secondary	198	148	4	none to 41 days	--	--
Na_2S	Primary	--	--	--	--	--	--
	Secondary	198	148	4	none to 41 days	--	--
Na_2SO_4	Primary	--	--	--	--	--	--
	Secondary	198	148	4	none to 41 days	--	--
$NaPO_3$	Primary	--	--	--	--	--	--
	Secondary	198	148	4	none to 41 days	--	--

* Samples stressed to 75% of Y.S. in holder.
Solution-treated, as-received material was aged for 200 hrs. in argon at 900°F.
Primary direction is direction of lowest Y.S. (transverse direction for this alloy).

TABLE IX

CUMULATIVE 4137 Co STRESS CORROSION BENT BEAM TESTS*

Natural Environment	Applied Stress on Specimen** Kpsi	Direction of Specimen	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
Marine Exposure	190+	Primary	3	3	8	3 to 16
Kure Beach, N.C.	160++	Primary	5	5	13	6 to 18
	130+++	Primary	5	none to 462 days	--	--
Semi-Industrial	190	Primary	5	5	19	2 to 30
Exposure	160	Primary	5	5	35	18 to 45
Monroeville, Pa.	130	Primary	5	none to 462 days	--	--

* Cooperative testing program with U. S. Steel Applied Research Lab., Monroeville, Pa.
** All specimens stressed to 75% of Y.S.

Note: These specimens were austenitized at 1700°F for 30 min and tempered at 550, 750 and 1100°F for 2 + 1 hrs producing Y.S. of 255, 213, and 174 Kpsi, respectively.
The primary direction is direction of lowest Y.S. (transverse for this alloy).

\+ 550°F Temper ++ 750°F Temper +++ 1100°F Temper

TABLE X

CUMULATIVE 4137 Co STRESS CORROSION BENT BEAM TESTS

Severe Industrial Exposure (Pittsburgh, Pennsylvania)

% of Y.S. for Test	Applied Stress on Specimen, Kpsi	Direction of Specimen	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
50	130+	Primary	6	4 to 335 days	--	--
	115 ++	Primary	5	none to 335 days	--	--
	95+++	Primary	6	none to 335 days	--	--
75	195	Primary	6	6	47.2	30 to 65
	175	Primary	6	4 to 335 days	--	--
	140	Primary	6	none to 335 days	--	--
90	230	Primary	6	6	33.6	21 to 43
	200	Primary	5	5	143.2	88 to 203
	170	Primary	6	none to 335 days	--	--

Note: These specimens were austenitized at 1700°F for 30 min and tempered at 550, 750 and 1100°F for 2 + 1 hrs producing Y.S. of 258, 232 and 191 Kpsi, respectively.
The primary direction is direction of lowest Y.S.

\+ 550°F Temper ++ 750°F Temper +++ 1100°F Temper

TABLE XI

CUMULATIVE 300M STRESS CORROSION U-BEND TESTS

Primary Heat
Low Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	-	-	-	-	--	--
	Secondary	200	-	6	none to 12 days	--	--
$NaNO_3$	Primary	-	-	-	-	--	--
	Secondary	200	-	6	none to 12 days	--	--
Na_2S	Primary	-	-	-	-	--	--
	Secondary	200	-	6	none to 12 days	--	--
Na_2SO_4	Primary	-	-	-	-	--	--
	Secondary	200	-	6	1 to 12 days	--	--
$NaPO_3$	Primary	-	-	-	-	--	--
	Secondary	200	-	6	6	3.0 hrs.	1 to 12 hrs.

* Y.S. estimated; tensile results not yet available.

Note: These specimens were austenitized at 1650° F for 20 min., oil quenched, and tempered at 1000° F for 2 + 2 hrs. with an air quench after each.
The primary direction is the direction of lowest Y.S. (transverse for this alloy).

TABLE XII

CUMULATIVE 300M STRESS CORROSION U-BEND TESTS

Primary Heat
Intermediate Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	-	-	-	-	--	--
	Secondary	220	-	5	none to 12 days	--	--
$NaNO_3$	Primary	-	-	-	-	--	--
	Secondary	220	-	5	none to 12 days	--	--
Na_2S	Primary	-	-	-	-	--	--
	Secondary	220	-	5	none to 12 days	--	--
Na_2SO_4	Primary	-	-	-	-	--	--
	Secondary	220	-	5	4 to 12 days	--	--
$NaPO_3$	Primary	-	-	-	-	--	--
	Secondary	220	-	5	5	12.0 min.	9 to 19 min.

* Y.S. estimated; tensile results not yet available.

Note: These specimens were austenitized at 1650°F for 20 min., oil quenched, and tempered at 800°F for 2 + 2 hrs. with an air quench after each.
The primary direction is the direction of lowest Y.S. (transverse for this alloy).

TABLE XIII

CUMULATIVE 300M STRESS CORROSION U-BEND TESTS

Primary Heat
High Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	240	-	6	6	9.2 min.**	1 to 30 min.
	Secondary	250	-	6	6	6.8 hrs.	8 min. to 27 hrs.
$NaNO_3$	Primary	240	-	6	6	15.0 hrs.	2 to 40 hrs.
	Secondary	250	-	6	6	31.9 hrs.	12 to 59 hrs.
Na_2S	Primary	240	-	6	none to 12 days	--	--
	Secondary	250	-	6	none to 12 days	--	--
Na_2SO_4	Primary	240	-	6	6	8.8 min.	4 to 16 min.
	Secondary	250	-	6	6	2.8 hrs.	15 min. to 12 hrs
$NaPO_3$	Primary	240	-	6	6	6.7 min.	5 to 8 min.
	Secondary	250	-	6	6	9.5 min.	5 to 13 min.

* Y.S. estimated; tensile results not yet available.
** One sample lasting 59.5 hrs. not averaged.

Note: These specimens were austenitized at 1650° F for 20 min., oil quenched, and tempered at 550° F for 2 + 2 hrs. with an air quench after each.
The primary direction is the direction of lowest Y.S. (transverse for this alloy).

TABLE XIV

CUMULATIVE 300M STRESS CORROSION U-BEND TESTS

Comparative Heat
High Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	-	-	-	-	--	--
	Secondary	250	-	6	6	65.5 hrs.	40.5 50 93.5 hrs.
$NaNO_3$	Primary	-	-	-	-	--	---
	Secondary	250	-	6	6	26.0 hrs.	12 to 40 hrs.
Na_2S	Primary	-	-	-	-	--	--
	Secondary	250	-	6	none to 12 days	--	--
Na_2SO_4	Primary	-	-	-	-	--	--
	Secondary	250	-	6	6	39.1 hrs.	12 to 58.5 hrs.
			-				
$NaPO_3$	Primary	-	-	-	-	--	--
	Secondary	250	-	6	6	16.2 min.	12 to 20 min.

* Y.S. estimated; tensile results not yet available.

Note: These specimens were austenitized at 1650° F for 20 min., oil quenched, and tempered at 550° F for 2 + 2 hrs. with an air quench after each.
The primary direction is the direction of lowest Y.S. (transverse for this alloy).

TABLE XV

CUMULATIVE AM355 STRESS CORROSION U-BEND TESTS

Low Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	224	277	6	2 to 55 days	--	--
	Secondary	250	261	6	none to 134 days	--	--
$NaNO_3$	Primary	224	277	6	none to 55 days	--	--
	Secondary	250	261	6	none to 134 days	--	--
Na_2S	Primary	224	277	6	none to 55 days	--	--
	Secondary	250	261	6	none to 134 days	--	--
Na_2SO_4	Primary	224	277	6	none to 55 days	--	--
	Secondary	250	261	6	none to 134 days	--	--
$NaPO_3$	Primary	224	277	6	none to 55 days	--	--
	Secondary	250	261	6	none to 134 days	--	--

Note: These specimens were cold-rolled to strength.
The outer surface of the specimen is stressed beyond its Y.S.
Primary direction is direction of lowest Y.S. (transverse direction of this alloy).
Specimen thickness - .038 inches.

TABLE XVI

CUMULATIVE AM355 STRESS CORROSION U-BEND TESTS

Intermediate Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	235	286	6	6	6.3	0.5 to 14.5
	Secondary	261	271	6	1 to 133 days	--	--
$NaNO_3$	Primary	235	286	6	none to 133 days	--	--
	Secondary	261	271	6	none to 133 days	--	--
Na_2S	Primary	235	286	6	none to 133 days	--	--
	Secondary	261	271	6	none to 133 days	--	--
Na_2SO_4	Primary	235	286	6	none to 133 days	--	--
	Secondary	261	271	6	none to 133 days	--	--
$NaPO_3$	Primary	235	286	6	none to 133 days	--	--
	Secondary	261	271	6	none to 133 days	--	--

Note: These specimens were cold-rolled to strength level.
The outer surface of the test specimen is stressed beyond its Y.S.
Primary direction is the direction of lowest Y.S. (transverse direction for this alloy).
Specimen thickness - .0365 inches.

TABLE XVII

CUMULATIVE AM355 STRESS CORROSION U-BEND TESTS

High Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	274	307	6	6	3.25	0.5 to 8
	Secondary	302	311	6	1 to 133 days	--	--
$NaNO_3$	Primary	274	307	6	none to 280 days	--	--
	Secondary	302	311	6	none to 133 days	--	--
Na_2S	Primary	274	307	6	none to 280 days	--	--
	Secondary	302	311	6	none to 133 days	--	--
Na_2SO_4	Primary	274	307	6	none to 280 days	--	--
	Secondary	302	311	6	none to 133 days	--	--
$NaPO_3$	Primary	274	307	6	none to 280 days	--	--
	Secondary	302	311	6	none to 133 days	--	--

Note: These specimens were cold-rolled to strength level.
The outer surface of the specimen is stressed beyond its Y.S.
Primary direction is direction of lowest Y.S. (transverse direction for this alloy).
Specimen thickness - .033 inches.

TABLE XVIII

CUMULATIVE PH15-7Mo STRESS CORROSION U-BEND TESTS

Low Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	201	238	6	none to 308 days	--	--
	Secondary	218	221	6	none to 308 days	--	--
$NaNO_3$	Primary	201	238	5	none to 308 days	--	--
	Secondary	218	221	6	none to 308 days	--	--
Na_2S	Primary	201	238	6	none to 308 days	--	--
	Secondary	218	221	6	none to 308 days	--	--
Na_2SO_4	Primary	201	238	5	none to 308 days	--	--
	Secondary	218	221	6	none to 308 days	--	--
$NaPO_3$	Primary	201	238	5	none to 308 days	--	--
	Secondary	218	221	6	none to 308 days	--	--

Note: These specimens are in the cold-rolled condition, as received.
The outer surface of the specimen is stressed beyond its Y.S.
Primary direction is direction of lowest Y.S.(transverse direction for this alloy).
Specimen thickness - 0.032 inches.

TABLE XIX

CUMULATIVE PH15-7Mo STRESS CORROSION U-BEND TESTS

Low-Intermediate Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	208	214	6	none to 110 days	--	--
	Secondary	224	229	6	none to 110 days	--	--
$NaNO_3$	Primary	208	214	6	none to 110 days	--	--
	Secondary	224	229	6	none to 110 days	--	--
Na_2S	Primary	208	214	6	none to 110 days	--	--
	Secondary	224	229	6	none to 110 days	--	--
Na_2SO_4	Primary	208	214	6	none to 110 days	--	--
	Secondary	224	229	6	none to 110 days	--	--
$NaPO_3$	Primary	208	214	6	none to 110 days	--	--
	Secondary	224	229	6	none to 110 days	--	--

Note: These specimens were tempered at 1125°F for 1 hr.
The outer surface of the specimens is stressed beyond its Y.S.
Primary direction is the direction of lowest Y.S. (transverse direction for this alloy).

TABLE XX

CUMULATIVE PH15-7Mo STRESS CORROSION U-BEND TESTS

High-Intermediate Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	244	254	6	none to 110 days	--	--
	Secondary	258	263	6	none to 110 days	--	--
$NaNO_3$	Primary	244	254	6	none to 110 days	--	--
	Secondary	258	263	6	none to 110 days	--	--
Na_2S	Primary	244	254	6	none to 110 days	--	--
	Secondary	258	263	6	none to 110 days	--	--
Na_2SO_4	Primary	244	254	6	none to 110 days	--	--
	Secondary	258	263	6	none to 110 days	--	--
$NaPO_3$	Primary	244	254	6	none to 110 days	--	--
	Secondary	258	263	6	none to 110 days	--	--

Note: These specimens were tempered at 1075°F for 1 hr.
The outer surface of the specimen is stressed beyond its Y.S.
Primary direction is direction of lowest Y.S. (transverse direction for this alloy).

TABLE XXI

CUMULATIVE PH15-7Mo STRESS CORROSION U-BEND TESTS

High Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	286	293	6	none to 110 days	--	--
	Secondary	289	290	6	none to 110 days	--	--
$NaNO_3$	Primary	286	293	6	none to 110 days	--	--
	Secondary	289	290	6	none to 110 days	--	--
Na_2S	Primary	286	293	6	none to 110 days	--	--
	Secondary	289	290	6	none to 110 days	--	--
Na_2SO_4	Primary	286	293	6	none to 110 days	--	--
	Secondary	289	290	6	none to 110 days	--	--
$NaPO_3$	Primary	286	293	6	none to 110 days	--	--
	Secondary	289	290	6	none to 110 days	--	--

Note: These specimens were tempered at 900°F for 1 hr.
The outer surface of the specimen is stressed beyond its Y.S.
Primary direction is direction of lowest Y.S. (transverse direction for this alloy).

TABLE XXII

CUMULATIVE PH15-7Mo AND AM355 STRESS CORROSION U-BEND TESTS

Test Solution	Type of Steel	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
Carbon tetrachloride CCl_4 (chlorinated non hydrocarbon)	PH15-7Mo	Primary	201	238	6	1 to 236 days	--	--
	PH15-7Mo	Secondary	218	221	6	none to 236 days	--	--
	AM355	Primary	274	307	6	none to 236 days	--	--
	AM355	Primary	235	286	6	none to 236 days	--	--
Pentane C_5H_{12} (non chlorinated hydrocarbon)	PH15-7Mo	Primary	201	238	6	none to 236 days	--	--
	PH15-7Mo	Secondary	218	221	6	none to 236 days	--	--
	AM355	Primary	274	307	6	none to 236 days	--	--
	AM355	Primary	235	286	6	none to 236 days	--	--
Trichloroethane C_2H_2Cl (chlorinated hydrocarbon)	PH15-7Mo	Primary	201	238	5	none to 236 days	--	--
	PH15-7Mo	Secondary	218	221	6	none to 236 days	--	--
	AM355	Primary	274	307	6	none to 236 days	--	--
	AM355	Primary	235	286	6	none to 236 days	--	--

Note: These specimens were cold-rolled to strength level.
The outer surface of the specimen is stressed beyond its Y.S.
Primary direction is the direction of lowest Y.S. (transverse direction for these alloys).

TABLE XXIII

CUMULATIVE B120VCA STRESS CORROSION U-BEND TESTS

Primary Heat
Low Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	139	140	4	none to 99 days	--	--
	Secondary	143	145	4	none to 391 days	--	--
$NaNO_3$	Primary	139	140	4	none to 99 days	--	--
	Secondary	143	145	4	none to 391 days	--	--
Na_2S	Primary	139	140	4	none to 99 days	--	--
	Secondary	143	145	4	none to 99 days	--	--
Na_2SO_4	Primary	139	140	4	none to 99 days	--	--
	Secondary	143	145	4	none to 99 days	--	--
$NaPO_3$	Primary	139	140	4	none to 99 days	--	--
	Secondary	143	145	4	none to 391 days	--	--

Note: These specimens are in the "as received" condition.
The outer surface of the specimen is stressed beyond its Y.S.
The primary direction is direction of lowest Y.S.

TABLE XXIV

CUMULATIVE B120VCA(HT1)* STRESS CORROSION U-BEND TESTS

Low Strength (Y.S.) Samples

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	141	143	4	none to 99 days	--	--
	Secondary	144	148	4	none to 99 days	--	--
$NaNO_3$	Primary	141	143	4	none to 99 days	--	--
	Secondary	144	148	4	none to 99 days	--	--
Na_2S	Primary	141	143	4	none to 99 days	--	--
	Secondary	144	148	4	none to 99 days	--	--
Na_2SO_4	Primary	141	143	4	none to 99 days	--	--
	Secondary	144	148	4	none to 99 days	--	--
$NaPO_3$	Primary	141	143	4	none to 99 days	--	--
	Secondary	144	148	4	none to 99 days	--	--

*HT1 refers to comparative heat number 1.

Note: These specimens were taken in the "as received" condition.
The outer surface of the specimen is stressed beyond its Y.S.
The primary direction is direction of lowest Y.S.

TABLE XXV

CUMULATIVE 4137 Co STRESS CORROSION U-BEND TESTS

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Primary	258	285	6	6	4.3	0.5 to 11.5
	Primary	232	260	6	6	126.0	38 to 224
	Primary	191	198	6	6	446.0	367 to 532
$NaNO_3$	Primary	258	285	6	6	1.2	0.5 to 1.5
	Primary	232	260	6	6	33.8	29.5 to 39.5
	Primary	191	198	6	6	122.6	26 to 292
Na_2S	Primary	258	285	5	2 to 365 days	--	--
	Primary	232	260	6	1 to 365 days	--	--
	Primary	191	198	6	none to 365 days	--	--
Na_2SO_4	Primary	258	285	6	6	0.9	10 min to 2.5 days
	Primary	232	260	5	5 to 499 days	--	--
	Primary	191	198	6	5 to 499 days	--	--
$NaPO_3$	Primary	258	285	6	6	4.5 min	3 to 6 min
	Primary	232	260	6	6	0.3 days*	34 min to 5 days
	Primary	191	198	6	6	1.5 days**	0.5 to 27 days

* One specimen lasting 5 days not averaged.
** One specimen lasting 27 days not averaged.

Note: These specimens were austenitized at 1700°F for 30 min and tempered at 550, 750 and 1100°F, respectively for 2 + 1 hrs.
The outer surface of the specimen is stressed beyond its Y.S.
The primary direction is direction of lowest Y.S.

TABLE XXVI

CUMULATIVE 4137 Co STRESS CORROSION U-BEND TESTS

Test Solution	Direction of Specimen	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
Dry Air (dessicator)	Primary	258	285	3	none to 366 days	--	--
	Primary	232	260	3	none to 366 days	--	--
	Primary	191	198	3	none to 366 days	--	--
Humid Air (satur. with water vapor)	Primary	258	285	4	4	6.4	4 to 11.5
	Primary	232	260	4	4	54.5	3 to 143
	Primary	191	198	4	none to 358 days	--	--
Laboratory (exposed directly to lab. environ.)	Primary	258	285	4	none to 358 days	--	--
	Primary	232	260	4	none to 358 days	--	--
	Primary	191	198	4	none to 358 days	--	--

Note: These specimens were austenitized at 1700°F for 30 min and tempered at 550, 750 and 1100°F, respectively for 2 + 1 hrs.
The outer surface of the specimen is stressed beyond its Y.S.
The primary direction is direction of lowest Y.S.

TABLE XXVII

CUMULATIVE ARDEFORM 301 STRESS CORROSION U-BEND TESTS

(Sample 1)

Test Solution	Direction of Specimen	Test Surface in Tension	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Long.	Outside (convex)	183	229	4	4	1.25	0.5 to 2.0
	Long.	Inside (concave)	183	229	4	3 to 280 days	--	--
	Trans.	Outside	--	--	6	none to 280 days	--	--
$NaNO_3$	Long.	Outside	183	229	4	none to 280 days	--	--
	Long.	Inside	183	229	4	none to 280 days	--	--
	Trans.	Outside	--	--	6	none to 280 days	--	--
Na_2S	Long.	Outside	183	229	4	none to 280 days	--	--
	Long.	Inside	183	229	4	none to 280 days	--	--
	Trans.	Outside	--	--	6	none to 280 days	--	--
Na_2SO_4	Long.	Outside	183	229	4	none to 280 days	--	--
	Long.	Inside	183	229	4	none to 280 days	--	--
	Trans.	Outside	--	--	6	none to 280 days	--	--
$NaPO_3$	Long.	Outside	183	229	4	none to 278 days	--	--
	Long.	Inside	183	229	4	none to 278 days	--	--
	Trans.	Outside	--	--	6	none to 278 days	--	--

Note: These specimens are in the "as received" condition.
The outer surface of the specimen is stressed beyond its Y.S.

TABLE XXVIII

CUMULATIVE ARDEFORM 301 STRESS CORROSION U-BEND TESTS

(Sample 2)

Test Solution	Direction of Specimen	Test Surface in Tension	Y.S. (.2% Offset) Kpsi	Tensile Strength Kpsi	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	Long.	Outside (convex)	209	235	6	2 to 250 days	--	--
	Long.	Inside (concave)	209	235	4	2 to 250 days	--	--
	Trans.	Outside	--	--	5	none to 250 days	--	--
$NaNO_3$	Long.	Outside	209	235	5	none to 250 days	--	--
	Long.	Inside	209	235	4	none to 250 days	--	--
	Trans.	Outside	--	--	5	none to 250 days	--	--
Na_2S	Long.	Outside	209	235	4	none to 250 days	--	--
	Long.	Outside	209	235	-	none to 250 days	--	--
	Trans.	Outside	--	--	5	none to 250 days	--	--
Na_2SO_4	Long.	Outside	209	235	4	none to 250 days	--	--
	Long.	Inside	209	235	3	none to 250 days	--	--
	Trans.	Outside	--	--	5	none to 250 days	--	--
$NaPO_3$	Long.	Outside	209	235	4	none to 250 days	--	--
	Long.	Inside	209	235	4	none to 250 days	--	--
	Trans.	Outside	--	--	5	none to 250 days	--	--

Note: These specimens are in the "as received" condition.
The outer surface of the specimen is stressed beyond the Y.S.

TABLE XXIX

CUMULATIVE U-MODIFIED 4137 Co U-BEND TESTS

High Strength (Y.S.) Samples

Test Solution	Sample Designation	Direction of Specimen	Tempering Temp., °F	No. of Specimens	Failures to Date	Average Time to Failure, days	Failure Time Range, days
NaCl	MV-38	Secondary	400	2	none to 146 days	--	--
	MV-38	Secondary	500	2	none to 146 days	--	--
	MV-38	Secondary	600	2	none to 146 days	--	--
NaCl	MV-40	Secondary	400	2	none to 146 days	--	--
	MV-40	Secondary	500	2	none to 146 days	--	--
	MV-40	Secondary	600	2	none to 146 days	--	--
NaCl	MV-41	Secondary	400	2	none to 146 days	--	--
	MV-41	Secondary	500	2	none to 146 days	--	--
	MV-41	Secondary	600	2	none to 146 days	--	--

Note: These samples were austenitized at 1700°F for 30 min., oil quenched, and tempered at 400, 500, and 600°F for 2 + 1 hours, an air quench following each temper.
The outer surface of the specimen is stressed beyond its Y.S.
The primary direction is the direction of lowest Y.S. (transverse for this alloy).

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